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ИЗМЕНЕНИЕ ФАЗОВОГО СОСТАВА И ПАРАМЕТРОВ РЕШЕТКИ СПЛАВА Ti–25Nb ПРИ ТЕРМИЧЕСКОЙ ОБРАБОТКЕ

Исследовался образец сплава Ti–25Nb. Для анализа фазовых превращений при термической обработке использовалось синхротронное излучение. Показано, что при нагревании α''-фаза переходит в промежуточную α'-фазу перед переходом в β-фазу.

Ключевые слова: биоматериалы, титановые сплавы, синхротрон

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PHASE COMPOSITION AND CHANGE OF LATTICE PARAMETERS OF Ti–25Nb DURING HEAT-TREATMENT

One Ti–25Nb sample has been researched. Synchrotron radiation was used to research the phase formation process during heat treatment in-situ. It was shown that during heating the α''-phase transform into an intermediate α'- phase before transforming into β-phase.

Key words: Ti alloys, metallic biomaterial, synchrotron

Ti–Nb alloys exhibit several technologically interesting mechanical and functional properties, such as a relatively low modulus and microhardness as well as shape memory effect for some particular compositions [1; 2]. The low Young's modulus together with the high biocompatibility is a key feature for the use of Ti–Nb alloys for application in medicine. The basis of the shape memory effect is a thermoelastic martensitic transformation between the high temperature body centred β phase and the orthorhombic α''-phase. A microstructure which fully consists of α''-phase is considered to exhibit a Young's modulus close to the Young's modulus of human bone.

With the use of metallic biomaterials which have a Young's modulus close to the modulus of human bone the so called "stress shielding effect" could be obsolete. The aim of the present work is to investigate the formation mechanisms during heat treatment of a Ti-Nb alloy.

One binary Ti–Nb alloy containing 25 wt. % Nb was synthesized using commercially pure Ti (VT1–0) and Nb (Nb-1). The initial materials were melted in a BUHLER arc furnace. The received button shaped alloy was remelted and suction cast into a cylindrical water-cooled copper crucible with a diameter of 5 mm. The diffraction studies with the use of synchrotron radiation were conducted in line P07 of the DESY electron synchrotron (Hamburg, Germany). The samples were placed in a dilatometer and heated (heating rate: 30 °C/min) to 900 °C, hold 10 min at 900 °C and then cooled (cooling rate: 50 °C/min) to RT. Further details about the alloy synthesis and the refinement procedure are given in [3].

The weight loss of the suction cast samples was found to be 0,44 % which indicates that the remelting process of initial Ti and Nb does not cause a change in composition. Selected SXRD patterns of the Ti–25Nb samples are plotted in Fig. 1.

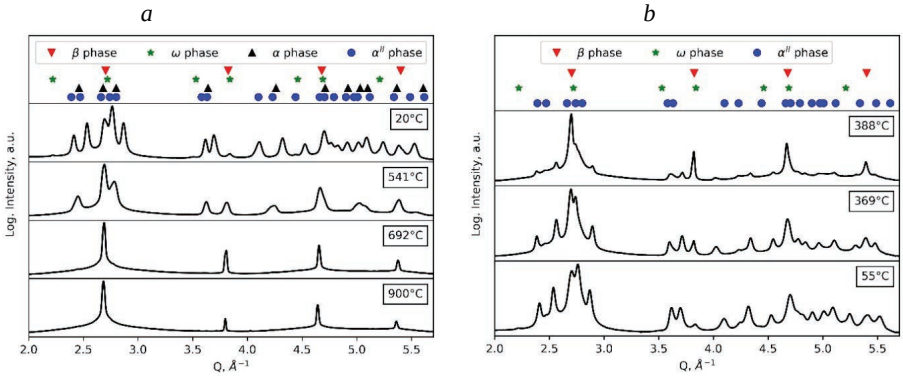

Fig. 1. Selected SXRD Patterns collected:
a — during heating and *b* — during cooling

From the SXRD patterns presented in Fig. 1, *a* (collected during heating) it can be seen that at RT in the sample a mixture of (α'' + β + ω)-phase was present. When the temperature was increased the α''-phase transformed into alpha/α' as an intermediate phase to the final high temperature β-phase. After a temperature of 541 °C the transformation α'' to α' was completed. At a

temperature of 692 °C the α' transformed completely to β-phase. Up to the holding temperature no further transformation took place. The SXRD patterns collected during cooling are presented in Fig. 1, *b*. When the temperature during cooling reaches 388 °C the formation of α''-phase starts. This martensitic transformation ends at a temperature of 369 °C. During further cooling no other phases form. The collection of SXRD patterns was stopped when the temperature reached 55 °C. At this temperature the sample mainly consists of a (α'' + β)-phase mixture accompanied with a minor amount of ω-phase.

In Table the lattice parameters of different phases are presented. It is obvious that most of the lattice parameters of α'' and ω are after the cooling process slightly bigger than before the heating. The lattice parameters of the β phase increase during heating and decrease during cooling, what follows the rules of expansion during heating.

Table

Lattice Parameters of different phases at different temperatures.

Temp., °C	α''-phase			α'-phase		β-phase	Ω-phase	
	a, Å	*b*, Å	*c*, Å	*a*, Å	*c*, Å	*a*, Å	*a*, Å	*c*, Å
20	3,060	4,958	4,670	–	–	3,275	4,635	2,831
541	–	–	–	2,966	4,702	3,298	–	–
692	–	–	–	–	–	3,305	–	–
900	–	–	–	–	–	3,262	–	–
388	3,127	4,927	4,633	–	–	3,292	–	–
369	3,122	4,902	4,668	–	–	3,289	4,622	2,891
55	3,071	4,952	4,662	–	–	3,276	4,640	2,835

The experimental results indicated that both the phase composition as well as the lattice parameters of the different phases depend strongly on the temperature. It was shown that a cooling rate of 50 °C/min is not high enough of to receive a volume fraction of ω phase as high as received after suction casting.

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Literature

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